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[54] METHOD AND APPARATUS FOR COLLECTING A SUBSTANCE

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5,254,266	10/1993	Barnes et al.	210/776
5,511,906	4/1996	Öberg	405/68

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[21] Appl. No.: **852,295**

[22] Filed: **May 7, 1997**

[51] Int. Cl.⁶ **C02F 1/02**

[52] U.S. Cl. **210/175; 210/774; 210/922; 210/923**

[58] Field of Search 210/175, 774, 210/922, 923

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[57] ABSTRACT

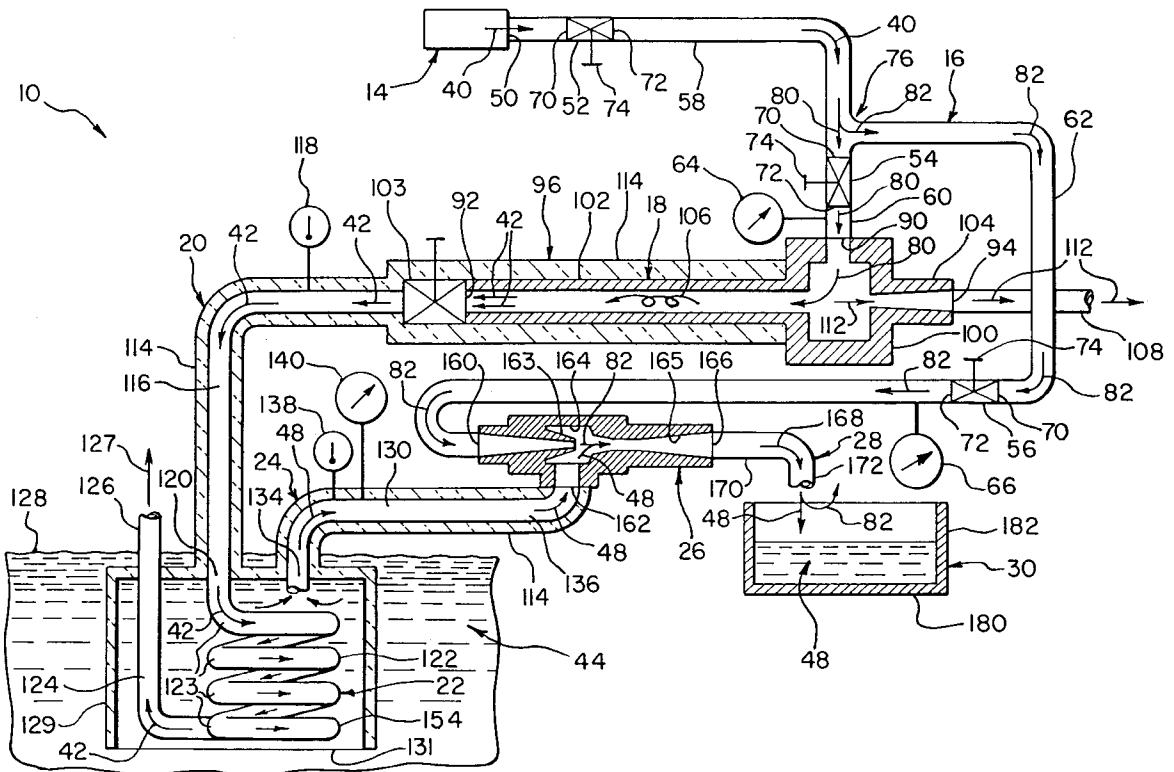
An apparatus for collecting a substance has a fluid source providing pressurized fluid, a heating device, a heat transferring device and a vacuum producing device. The heating device is coupled to the fluid source and is adapted to cause a first pressurized fluid from the fluid source to become heated. The heat transferring device is coupled to the heating device for receiving the heated first pressurized fluid, and is adapted for transferring heat from the first pressurized fluid to a heatable substance. The vacuum producing device has first and second inlet openings, the first inlet opening is fluidly coupled to the fluid source for receiving a second pressurized fluid from the fluid source and the second inlet opening is adapted for receiving the heatable substance.

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22 Claims, 3 Drawing Sheets



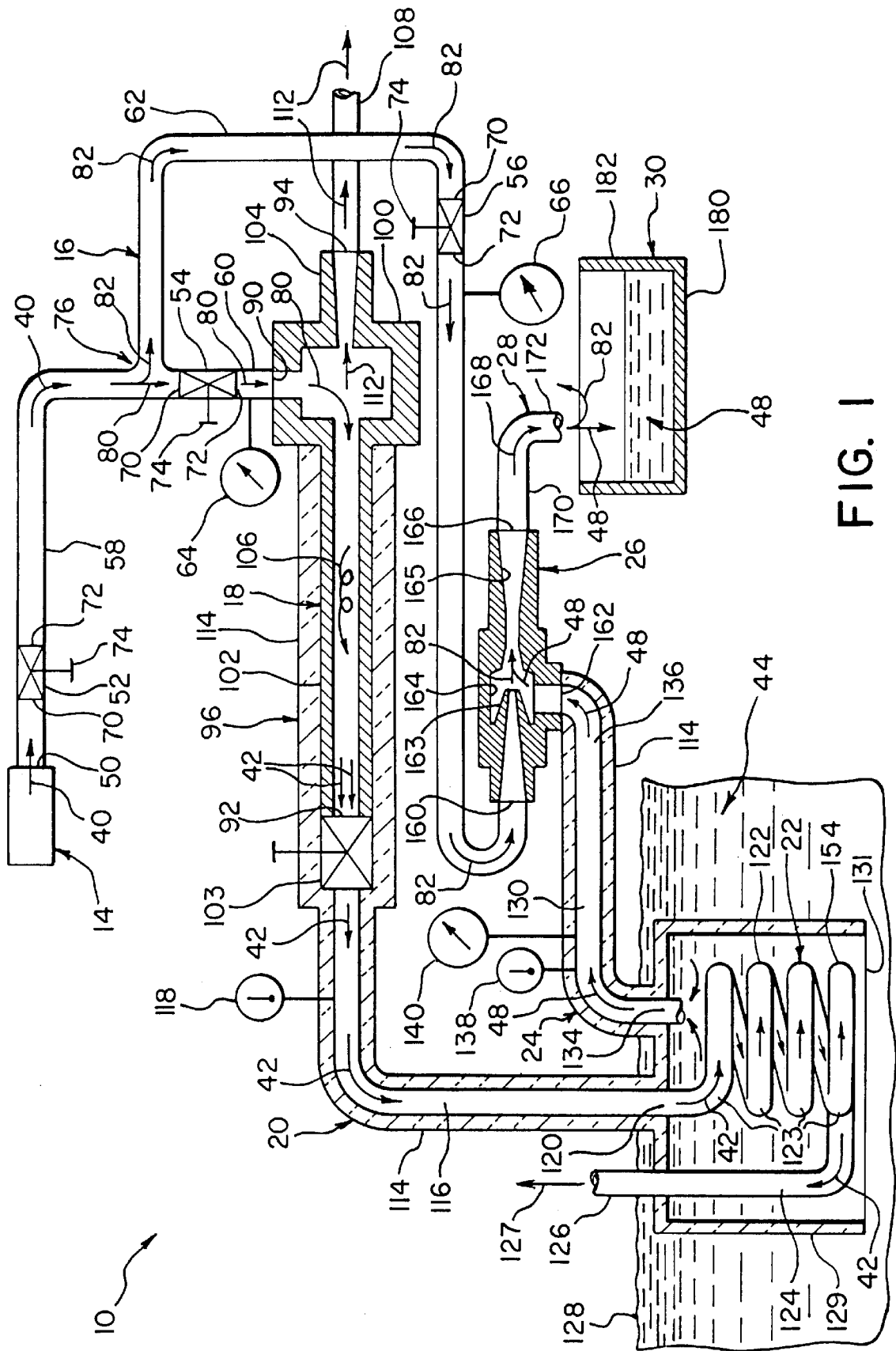


FIG. 1

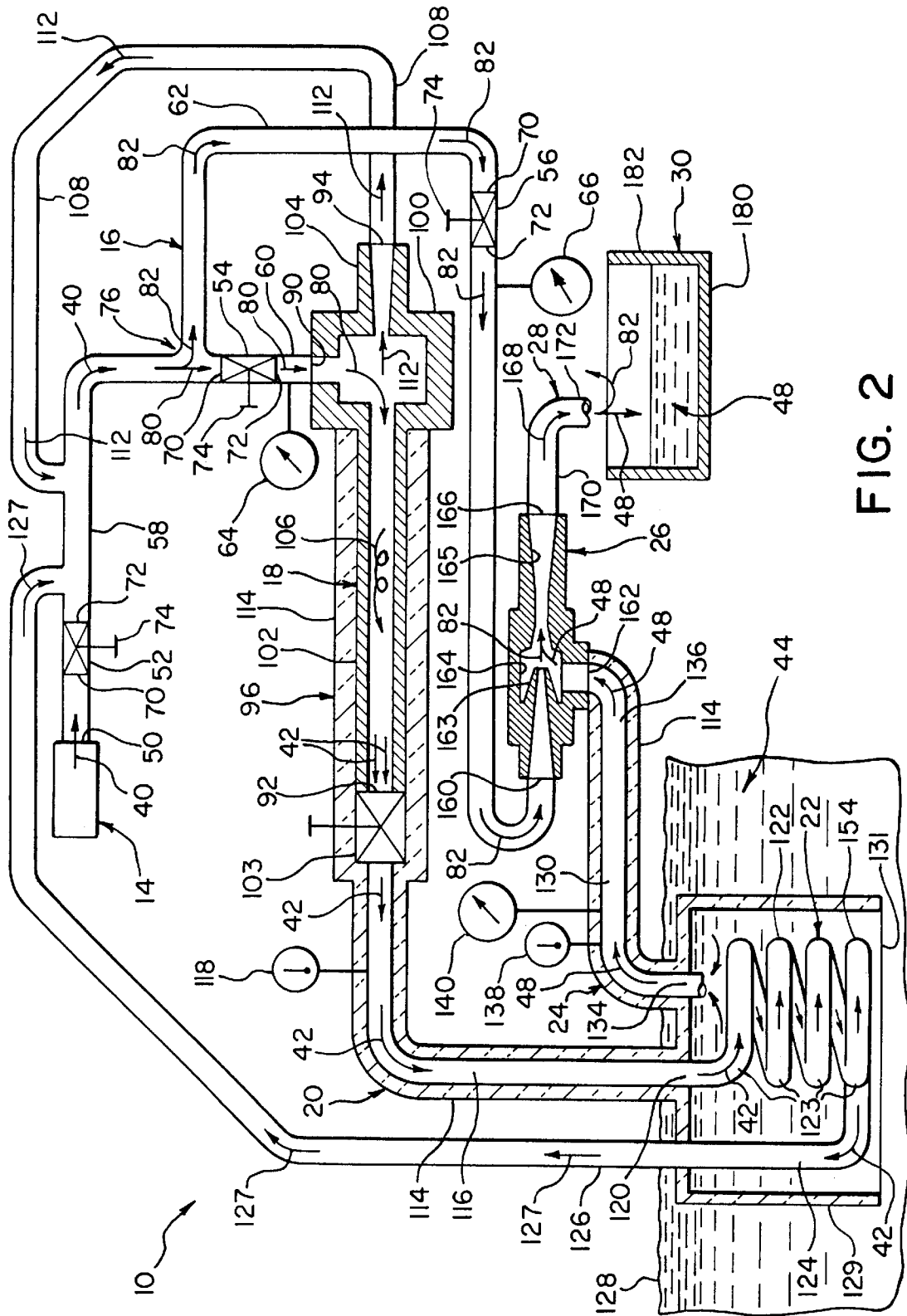


FIG. 2

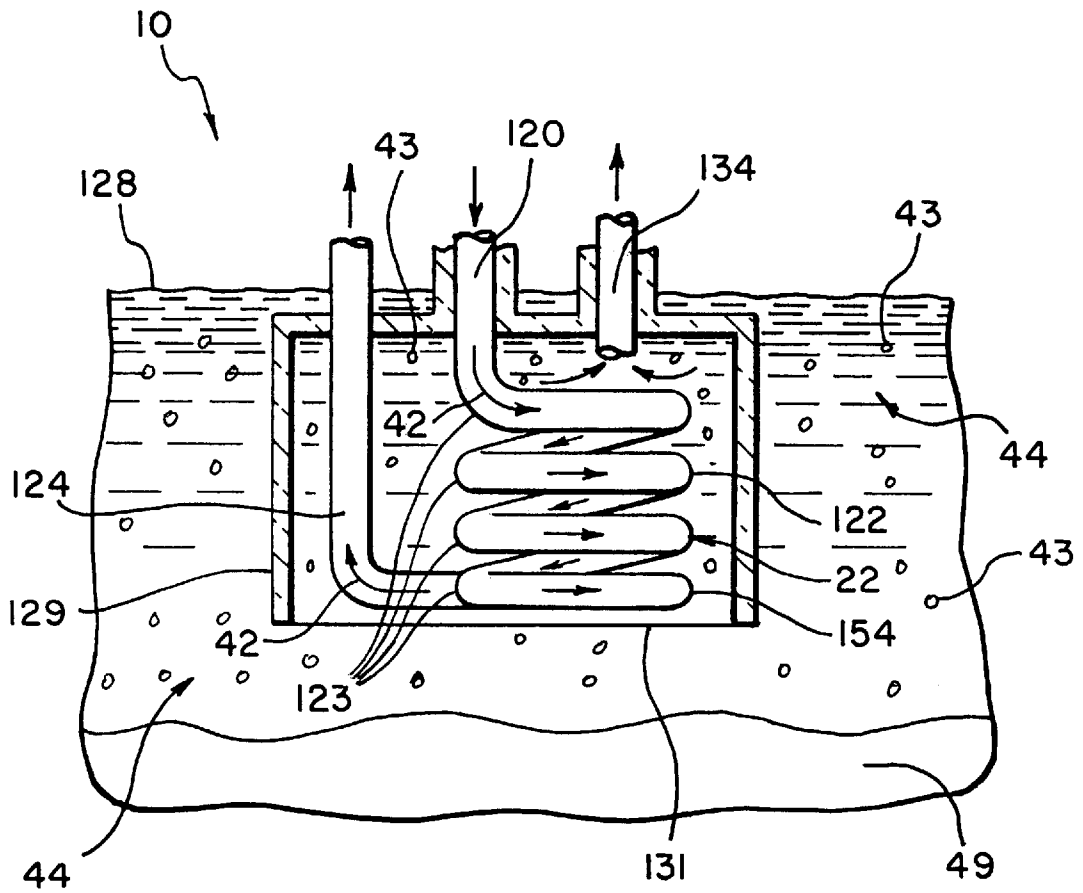


FIG. 3

METHOD AND APPARATUS FOR COLLECTING A SUBSTANCE

FIELD OF THE INVENTION

The invention generally relates to a method and apparatus for collecting a substance. More specifically, the invention relates to a method and apparatus for retrieving spilled oil using a heating device and a vacuum forming device, both devices having only stationary elements.

BACKGROUND OF THE INVENTION

The pollution of the environment by spilling harmful substances, either intentionally or unintentionally, can cause significant damage to the environment. This is especially true if the harmful substances are not quickly retrieved. One of the more commonly spilled pollutants is oil. Large quantities of oil are spilled on both land and sea in a variety of ways. For instance, oil can be spilled during on-shore and off-shore oil exploration, by accidents occurring during the transportation of oil both on land and on sea, and even through the normal, but inefficient, use of oil. Whatever the reason for the oil spill, it is of great environmental concern to retrieve the spilled oil quickly and efficiently, and clean the polluted areas.

There exists many conventional devices for retrieving spilled substances such as oil. These conventional retrieving devices commonly employ various absorption, suction, centrifugal and skimming techniques. However, conventional retrieving devices suffer from a number of disadvantages. In particular, conventional retrieving devices are often complex, expensive devices that are difficult to operate, prone to breaking down, and not easily fixed. These disadvantages become especially problematic during lengthy clean-ups of large spills. Additionally, conventional devices are not generally versatile. Often, they are designed for specific environments, i.e., calm waters, and/or they have a small capacity. Further, conventional devices often experience great difficulty in handling high viscous oils or oil made more viscous due to being spilled in cold environments.

Examples of prior art oil spill retrieval systems are disclosed in the following U.S. Pat. No. : 3,726,406 to Damberger; U.S. Pat. No. 3,831,756 to Bhuta et al.; U.S. Pat. No. 3,922,225 to Strain; U.S. Pat. No. 4,316,805 to Faust et al.; U.S. Pat. No. 5,035,536 to von Winckelmann; U.S. Pat. No. 5,215,407 to Brelsford; U.S. Pat. No. 5,254,266 to Barnes et al.; and U.S. Pat. No. 5,511,906 to Öberg.

In view of the above, it is apparent that there exists a need for a method and apparatus for collecting a substance that is simple, inexpensive, efficient and capable of retrieving substances that are highly viscous. This invention addresses these needs in the art, along with other needs, which will become apparent to those skilled in the art once given this disclosure.

SUMMARY OF THE INVENTION

Accordingly, an object of the present invention is to provide a simple, inexpensive method and apparatus for collecting a substance.

Another object of the present invention is to provide a versatile method and apparatus for collecting large volumes of spilled pollutants over a wide range of physical environments.

Still another object of the present invention is to provide a method and apparatus for collecting spilled oil that is highly viscous and/or is located in cold environments.

Still another object of the present invention is to provide a collecting method and apparatus that involves supplying a pressurized fluid to elements that have no moving parts.

Yet another object of the present invention is to provide a collecting method and apparatus that employs, either singularly or together, a vortex tube for supplying a heated fluid, and a jet pump for supplying suction.

A further object of the present invention is to provide a collecting method and apparatus that delivers pressurized gas from a single source to a system having elements that only require pressurized gas to operate, and that function with no moving parts.

The foregoing objects are basically attained by providing an apparatus for collecting a substance, comprising a fluid source for providing a first and second pressurized fluid; a heating device coupled to the fluid source and being adapted to heat the first pressurized fluid from the fluid source; a heat transferring device coupled to the heating device for receiving the heated first pressurized fluid, and being adapted for transferring heat from the first pressurized fluid to a heatable substance; and a vacuum producing device having first and second inlet openings, the first inlet opening fluidly coupled to the fluid source for receiving a second pressurized fluid from the fluid source and the second inlet opening being adapted for receiving the heatable substance.

The foregoing objects are also attained by providing an apparatus for collecting a substance, comprising a fluid source for providing a first and second pressurized fluid; a heating device having a first aperture fluidly coupled to the fluid source, a second aperture, and a connecting portion positioned between the first and second apertures and fluidly coupling the first and second apertures together, and the connecting portion configured such that a vortex is formed within the heating device by the first pressurized fluid from the fluid source and such that the first pressurized fluid becomes heated within the heating device; a heat transferring device fluidly coupled to the second aperture of the heating device for receiving the heated first pressurized fluid, and the heat transferring device being adapted for transferring heat from the first fluid to a heatable substance; and a vacuum producing device adapted for extracting the heatable substance from an area around the heat transferring device.

The foregoing objects are further attained by providing a method of collecting a substance, comprising the steps of supplying a first pressurized fluid from a source of pressurized fluid to a heating device; passing the first pressurized fluid through the heating device to heat the first pressurized fluid; directing the first pressurized fluid which is heated from the heating device to a heat transferring device; transferring heat from the first pressurized fluid to a heatable substance; supplying a second pressurized fluid from the source of pressurized fluid to a first inlet opening of a vacuum forming device; forming suction by passing the second pressurized fluid through the vacuum forming device; extracting the heatable substance from an area around the heat transferring device by suction; and directing the heatable substance through a second inlet opening of the vacuum forming device.

Other objects, advantages and salient features of the invention will become apparent to those skilled in the art from the following detailed description which, taken in conjunction with the annexed drawings, discloses preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWING

Referring now to the attached drawing which forms a part of this original disclosure:

FIG. 1 is a schematic representation of an apparatus for collecting a substance in accordance with the present invention, including illustrating schematic cross-sectional views of the vortex tube, jet pump, reservoir, insulation and insulating housing;

FIG. 2 is a schematic representation similar to FIG. 1, but illustrating an apparatus for collecting a substance in accordance with a second embodiment of the present invention where the pressurized fluid exiting the vortex tube, heat exchanger and jet pump are returned to the supply conduit system; and

FIG. 3 is a partial schematic representation illustrating the heat exchanger being positioned in a mixture of oil and sand, which is supported only by sand.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. 1, an apparatus 10 for collecting a substance in accordance with the present invention is illustrated. Apparatus 10 is especially useful in collecting oil from a body of fluid or water, and basically includes a fluid source 14, a supply conduit system 16, a vortex tube 18, a hot fluid conduit system 20, a heat exchanger 22, a vacuum conduit system 24, a jet pump 26, a transporting conduit system 28 and a reservoir 30. As discussed in greater detail below, fluid source 14 provides pressurized fluid 40 simultaneously to both vortex tube 18 and jet pump 26 via supply conduit system 16. Hot fluid 42 is discharged from vortex tube 18 and is directed to heat exchanger 22 via hot fluid conduit system 20. Heat exchanger 22 is submerged in a heatable substance to be retrieved, such as spilled oil 44 located on a body of water. Heat exchanger 22 allows heat to be transferred from hot fluid 42 to spilled oil 44; thus, making spilled oil 44 less viscous. The portion of pressurized fluid 40 received by jet pump 26 creates a vacuum within jet pump 26 for suctioning and retrieving spilled oil 44 from an area around heat exchanger 22. Retrieved oil 48 is then forced through jet pump 26 via vacuum conduit system 24 and then proceeds through transporting conduit system 28 to reservoir 30.

Fluid source 14 is illustrated schematically in FIG. 1 as a means for providing pressurized fluid 40. Pressurized fluid 40 exits fluid source 14 through an outlet 50 and enters supply conduit system 16. Pressurized fluid 40 supplied by fluid source 14 can take the form of any appropriate, compressible gas, vapor, or liquid as necessary and/or desired. Fluid source 14 can be any source of compressible, pressurized fluid that is currently known in the art, or that will be known in the art so long as fluid source 14 provides the desired quantity of the desired compressible, pressurized fluid 40 at the desired pressure levels. Accordingly, fluid source 14 will not be described in detail herein.

Although fluid source 14 is illustrated schematically as a single fluid source, it should be understood that fluid source 14 encompasses multiple fluid sources that can be used in series to provide the desired pressurized fluid 40. Also, as discussed below, fluid source 14 can comprise multiple, separate fluid sources that can be used for supplying a distinct pressurized fluid to each of vortex tube 18 and jet pump 26. This is especially useful when it is desired to supply a different type of pressurized fluid 40 to each of vortex tube 18 and jet pump 26. Preferably, the pressurized fluid 40 supplied to both vortex tube 18 and jet pump 26 is pressurized air.

Supply conduit system 16 includes valves 52, 54 and 56, pipe sections 58, 60 and 62 and pressure gauges 64 and 66.

Since valves 52, 54 and 56, pipe sections 58, 60 and 62 and pressure gauges 64 and 66 are conventional and well-known in the art, they will only be briefly described herein. Valves 52, 54 and 56 are preferably substantially identical to each other and made from metallic material. However, different sizes may be employed, as well as different types so long as the basic function of valves 52, 54 and 56 as discussed below is maintained. Each valve 52, 54 and 56 has a valve inlet 70, a valve outlet 72 and a control lever 74 for adjusting the flow of fluid therethrough. Each valve 52, 54 and 56 enables selective control of pressurized fluid 40 passing therethrough to the extent that each valve 52, 54 and 56 can maintain a completely open position, a completely closed position prohibiting pressurized fluid 40 from passing therethrough, and any extent of restricted position between the open and closed positions. Valves 52, 54 and 56 are connected to pipe sections 58, 60 and 62, respectively, in a conventional manner, such as by threaded, mating male and female elements.

Pipe section 58 extends between fluid source 14 and a pipe intersection 76. At pipe intersection 76, pipe section 58 is fluidly coupled to pipe section 60 which leads to vortex tube 18 and to pipe section 62 which leads to jet pump 26. Pipe sections 58, 60 and 62 are preferably metallic, and cylindrical. The connections between fluid source 14, vortex tube 18 and jet pump 26 and their respective adjacent pipe sections 58, 60 and 62, as well as the connections between pipe sections 58, 60 and 62 at pipe intersection 76 are conventional and well-known in the art. Preferably, these connections are between threaded, mating male and female elements.

Valve 52 allows direct control on the amount of pressurized fluid 40 delivered from fluid source 14 into supply conduit system 16. When apparatus 10 is in use, valve 52 permits pressurized fluid 40 to pass therethrough. Upon exiting valve 52, pressurized fluid 40 proceeds to pipe intersection 76 and splits into two pressurized fluid lines; a first supply fluid 80 and a second supply fluid 82.

First supply fluid 80 enters pipe section 60 and proceeds to valve 54. If apparatus 10 is in use, valve 54 is placed in the open position and first supply fluid 80 proceeds therethrough. As first supply fluid 80 passes through valve 54, first fluid 80 continues through pipe section 60 until reaching vortex tube 18. Prior to reaching vortex tube 18, the pressure of first supply fluid 80 is measured by pressure gauge 64. The particular location of pressure gauge 64 is convenient for enabling an operator to determine the extent to which valve 54 is restricting or permitting flow of first supply fluid 80 therethrough, and the precise pressure of first supply fluid 80 entering vortex tube 18.

Second supply fluid 82 continues from pipe intersection 76, through pipe section 62, to valve 56. If apparatus 10 is in use, valve 56 will be in the open position to permit the desired amount of second supply fluid 82 to pass therethrough. After passing through valve 56, second supply fluid 82 continues proceeding through pipe section 62 to jet pump 26. After leaving valve 56, the pressure of second supply fluid 82 is measured by pressure gauge 66 which is substantially identical to pressure gauge 64. In a manner similar to that discussed above with respect to valve 54 and pressure gauge 64, pressure gauge 66 allows an operator to obtain a direct measurement of the amount of second supply fluid 82 passing through valve 56 and into jet pump 26.

As mentioned above, as an alternative embodiment of the configuration of supply conduit system 16, fluid source 14 can be split into two distinct fluid sources. One fluid source

(not shown) can provide first supply fluid **80** directly to vortex tube **18** through pipe section **60**, while a second fluid source (not shown) can provide second supply fluid **82** directly to jet pump **26** through pipe section **62**.

Vortex tube or heating device **18** has at least one inlet aperture or inlet **90**, at least one hot fluid outlet aperture or hot fluid outlet **92**, a cold fluid outlet **94**, and a connecting portion or vortex chamber **96** positioned between outlets **92** and **94**. Vortex chamber **96** has an initiation portion **100**, a containing portion **102** and a passage portion **104**, and provides a fluid coupling between inlet **90** and both hot fluid outlet **92** and cold fluid outlet **94**.

Vortex tube **18** is also known in the art as a Ranque tube, a Hilsch tube or a vortex refrigerator. Vortex tube **18** is conventional and known in the art, and thus, is only shown schematically in FIG. **1** and will only be described briefly herein. Vortex tube **18** has no moving parts, i.e., it is formed entirely of stationary elements, and relies upon the formation of a vortex **106** within vortex chamber **96** which provides hot fluid **42** as well as a cold fluid **112**.

U.S. Pat. No. 1,952,281 to Ranque, issued on Mar. 27, 1934 discloses examples of apparatus for obtaining two currents of fluids at different temperatures, i.e., vortex tubes, that can be employed in the present invention. Accordingly, U.S. Pat. No. 1,952,281 to Ranque is hereby incorporated her particular, those portions of U.S. Pat. No. 1,952,281 to Ranque pertaining to the structure and function of the apparatus for obtaining two currents of fluids at different temperatures, or the vortex tubes, are hereby incorporated herein by reference. It should be understood that other configurations for vortex tubes can be employed in apparatus **10** as long as the desired amount of hot fluid **42** is produced.

First supply fluid **80** passes from pipe section **60**, through inlet **90** of vortex tube **18**, and proceeds into initiation portion **100**. Initiation portion **100** is configured such that it directs first supply fluid **80** into a vortex **106** within containing portion **102**. Inlet **90** can comprise a single inlet aperture or multiple inlet apertures that are fluidly coupled to pipe section **60** for forming vortex **106**.

As mentioned above, vortex **106** provides both hot fluid **42** and cold fluid **112**. Hot fluid **42** is formed around the outer areas of vortex **106** and is discharged from containing portion **102** to hot fluid conduit system **20** via valve **103**. Meanwhile, cold fluid **112** is formed around the inner areas of vortex **106** and flows back towards initiating portion **100**. Cold fluid **112** proceeds through passage portion **104** to cold exhaust pipe section **108** and to the ambient atmosphere. Cold exhaust pipe section **108** is a conventional pipe section attached to passage portion **104** in a conventional manner and is substantially identical to pipe sections **58**, **60** and **62**, discussed above.

Outlet **92** of containing portion **102** preferably has multiple openings (not shown) that lead to valve **103** and that are positioned around the perimeter of containing portion **102**. Since the openings of outlet **92** are located adjacent the outer portion of vortex **106**, only hot fluid **42** on the outer portion of vortex **106** passes through the openings of outlet **92**, while cold fluid **112** on the inside of vortex **106** continues through initiation portion **96** and into passage portion **104**.

Valve **103** is a conventional throttling valve positioned between containing portion **102** and hot fluid conduit system **20** and is connected to both in a conventional manner. Valve **103** enables the selective determination of the amount of hot fluid **42** to pass from vortex tube **18** to hot fluid conduit system **20**. The amount and temperature of hot fluid **42**

flowing into hot fluid conduit system **20** is determined, in part, by the amount of hot fluid **42** permitted to pass through valve **103**. Additionally, varying the flow of first supply fluid **80** through valve **54** and into vortex tube **18** also provides a method for varying both the pressure and the temperature of hot fluid **42** exiting containing portion **102**. This manipulation of vortex tube **18** is conventional and known in the art. Further, in order to maintain hot fluid **42** at a high temperature, both containing portion **102** and valve **103** can be surrounded by insulation **114** as discussed below.

As hot fluid **42** exits vortex tube **18**, it enters hot fluid conduit system **20**. Hot fluid conduit system **20** comprises a single pipe section **116** and a temperature gauge **118** connected thereto. Pipe section **116** is similar to pipe sections **58**, **60**, **62** and **108** as discussed above, and provides a conduit for hot fluid **42** to travel from valve **103** to heat exchanger **22**. Pipe section **116** and heat exchanger **22** are connected in a conventional manner. Also, pipe section **116** can be surrounded by insulation **114** as further discussed below.

Temperature gauge **118** is schematically shown in FIG. **1** and is conventional and well-known in the art. Thus, temperature gauge **118** will not be described in detail herein. Temperature gauge **118** measures the temperature of hot fluid **42** as it exits valve **103** and proceeds through pipe section **116**. Temperature gauge **118** and valve **103** enable an operator of apparatus **10** to determine the temperature of hot fluid **42** proceeding to heat exchanger **22** after restricting or increasing the flow of hot fluid **42** through valve **103**.

Heat exchanger or heat transferring device **22** comprises an inlet **120**, a helical coil **122** with circular sections **123**, and an exhaust portion **124** with an exhaust outlet **126**. Inlet **120** is submerged within spilled oil **44** and receives hot fluid **42** from pipe section **116**. Hot fluid **42** proceeds past inlet **120** to helical coil **122** and to exhaust portion **124**. Preferably, heat exchanger **22** is made of metallic pipe and is substantially identical to pipe sections **58**, **60**, **62**, **108** and **116** as described above, except for its overall shape. Alternatively, since a portion of pipe section **116** and heat exchanger **22** are submerged in spilled oil **44**, they may be made of a more durable, corrosion-resistant material.

Heat exchanger **22** is preferably completely submerged within spilled oil **44** except for exhaust outlet **126**. Since heat exchanger **22** is substantially submerged in spilled oil **44**, a maximum amount of heat is transferred from hot fluid **42** to spilled oil **44**. Also, helical coil **122** is a spiral comprised of multiple, generally circular sections **123** forming a curve in a cylindrical form. Circular sections **123** are spaced from each other so that spilled oil **44** can completely surround the entire surface of helical coil **122** and receive an optimal amount of heat therefrom. Exhaust portion **124** is fluidly coupled to the bottommost circular section **154** and extends upwards to exhaust outlet **126** which is above the surface **128** of spilled oil **44**. Exhaust outlet **126** enables hot fluid **42** to be discharged into the atmosphere as a released fluid **127**. Released fluid **127** having transferred heat to spilled oil **44** as it passed through heat exchanger **22** as hot fluid **42**.

Although heat exchanger **22** has been described as having a helical coil **122** and being spirally shaped, it should be understood that heat exchanger **22** can take any shape and configuration that adequately transfers heat to spilled oil **44**. The configuration of heat exchanger **22** illustrated in FIG. **1** is merely one example of a heat exchanger that can be employed by the invention. Further, heat exchanger **22** can be made of various materials to improve its ability to transfer

heat. The main purpose of heat exchanger 22 is merely to transfer heat from hot fluid 42 to spilled oil 44 so that the viscosity of spilled oil 44 is decreased; thus, allowing spilled oil 44 to be more easily suctioned into vacuum conduit system 24 as discussed below.

If desired, heat exchanger 22 can be partially enclosed by an insulating housing 129 to maintain the heat transferred by heat exchanger 22 within the spilled oil 44 that is adjacent helical coil 122. Insulating housing 129 is formed of conventional insulating material and prevents heat from heat exchanger 22 from being widely dispersed throughout large quantities of spilled oil 44. Also, insulating housing 129 concentrates the heat so that spilled oil 44 in an area immediately adjacent to helical coil 122 receives more heat and is less viscous. Insulating housing 129 has a bottom opening 131 that allows additional spilled oil 44 to enter the area adjacent heat exchanger 22 and eventually be suctioned out from around heat exchanger 22 through vacuum conduit system 24. As exhaust outlet 124 extends upwardly towards the surface 128 of spilled oil 44, it extends through insulating housing 129.

Although insulating housing 129 is illustrated as enclosing the top and sides of heat exchanger 22, other configurations of insulating housing 129 may be employed. For instance, insulating housing 129 may be partially removed from around heat exchanger 22, or may be adapted with apertures to allow spilled oil 44 to gain easier access to heat exchanger 22. Alternatively, insulating housing 129 can be completely removed from around heat exchanger 22.

Vacuum conduit system 24 comprises a pipe section 130 having an inlet 134 located in the spilled oil 44 and an outlet 136 connected to jet pump 26. Vacuum conduit system 24 also has a temperature gauge 138 and a vacuum pressure gauge 140 connected to pipe section 130. Pipe section 130 is substantially identical to pipe sections 58, 60, 62, 108 and 116 discussed above, and is preferably covered by insulation 114 in a similar manner as pipe section 116. Temperature gauge 138 is substantially identical to temperature gauge 118 discussed above, and vacuum gauge 140 is a conventional vacuum gauge that is known in the art and that adequately measures the vacuum pressure produced by jet pump 26. Thus, temperature gauge 138 and vacuum gauge 140 will not be discussed in detail herein. Vacuum gauge 140 is similar to pressure gauges 64 and 66 discussed above but measures negative, vacuum pressure instead of positive pressure.

Inlet 134 of pipe section 130 is supported in a conventional manner and submerged within spilled oil 44 in close proximity to heat exchanger 22. Thus, inlet 134 receives spilled oil 44 which is in close proximity to heat exchanger 22 and which has received an optimal amount of heat from heat exchanger 22. The spilled oil 44 entering pipe section 130 then becomes retrieved oil 48. Pipe section 130 then provides a fluid coupling from the area around heat exchanger 22, up above surface 128 of spilled oil 44, to jet pump 26. Pipe section 130 and jet pump 26 are connected in a conventional manner, and since pipe section 130 is preferably covered with insulation 114, the retrieved oil 48 within pipe section 130 remains heated and in a state of low viscosity. Temperature gauge 138 is connected to pipe section 130 and measures the temperature of retrieved oil 48 passing within and through pipe section 130.

As discussed above, those portions of apparatus 10 that act as conduits for hot fluid 42 or retrieved oil 48 are surrounded by thermal insulation 114 to decrease the amount of heat loss from hot fluid 42 or retrieved oil 48 to its

respective surrounding environment. Insulation 114 is especially helpful in cold environments such as in arctic regions. Insulation 114 extends completely around containing portion 102, valve 103, pipe section 116 and pipe section 130, preferably in an integral manner. Further, insulation 114 is preferably integrally connected with insulating housing 129. Insulation 114 and insulating housing 129 are preferably made from the same insulating material which can be any conventional insulating material that is adequate for the intended use. A more durable insulating material can be used where the insulating material will be exposed to or submerged in spilled oil 44.

Jet pump or vacuum producing device 26 has a first pressurized fluid inlet opening 160, a second heatable substance inlet opening 162, a conical nozzle 163, a cylindrical mixing cavity 164, a conical throat 165 and an outlet opening 166. Jet pump 26 is an ejector, or more specifically, a venturi eductor. Jet pump 26 is conventional and well-known in the art and, therefore, will only be described briefly herein.

Jet pump 26 has no moving parts, i.e., it is formed entirely of stationary elements. Second supply fluid 82 enters jet pump 26 through first inlet opening 160 and proceeds to mixing cavity 164 through nozzle 163. As second supply fluid 82 passes, at high pressure, through mixing cavity 164 and throat 165 towards outlet opening 166, a vacuum is formed creating suction from second inlet opening 162 towards mixing cavity 164. This suction provides the force necessary to extract spilled oil 44 from around heat exchanger 22 and into pipe section 130 and for forcing retrieved oil 48 to jet pump 26. Depending upon the level of suction created, jet pump 26 is capable of sucking any fluid therethrough, including loose particles and powdery material.

Jet pump 26 can be configured in any number of ways as is known in the art. For example, although FIG. 1 illustrates jet pump 26 receiving second supply fluid 82 in the same direction that mixture 168 exits jet pump 26, jet pump 26 can be configured such that second supply fluid 82 enters jet pump 26 in a direction that is perpendicular to the direction that mixture 168 exits jet pump 26. An example of such an alternative jet pump 26 configuration is disclosed in U.S. Pat. No. 4,487,553 to Nagata issued Dec. 11, 1984 which is hereby incorporated herein by reference. Specifically, those portions of U.S. Pat. No. 4,487,553 to Nagata pertaining to the structure and function of jet pumps are hereby incorporated herein by reference.

Jet pumps or venturi eductors 26 are commercially available from numerous sources and in various sizes. In particular, where a maximum vacuum of 24 inches of mercury is sufficient, Mini Vacuum Pump VR05 from Anver Corporation, Hudson, Mass. is an example of one type of jet pump that can be employed with apparatus 10. However, it should be understood that jet pump 26 will be configured and sized as necessary and/or desired for the particular application of apparatus 10, and specifically, for the desired vacuum pressure.

The amount of suction created by jet pump 26 is measured by vacuum gauge 140 and controlled by the amount of second supply fluid 82 passing through valve 56 and into first inlet opening 160. Thus, an operator of apparatus 10 can restrict or increase flow through valve 56 while observing the actual pressure of second supply fluid 82 entering inlet opening 160 through the use of pressure gauge 66, and while observing the actual vacuum pressure within pipe section 130 by viewing vacuum gauge 140.

After retrieved oil 48 proceeds through pipe section 130 and through inlet opening 162, retrieved oil 48 mixes with second supply fluid 82 within mixing cavity 164 to form a mixture 168. Preferably, mixture 168 is a mixture of air and oil. Mixture 168 is then forced from mixing cavity 164, through throat 165 and outlet 166, to transporting conduit system 28 by the pressure of second supply fluid 82.

Transporting conduit system 28 comprises pipe section 170 having outlet 172. Pipe section 170 is preferably, substantially identical to pipe sections 58, 60, 62, 108, 116 and 130 above and is connected to jet pump 26 in a conventional manner. Pipe section 170 provides a fluid conduit for mixture 168 from outlet opening 166 of jet pump 26 to outlet 172. As mixture 168 passes through outlet 172, second supply fluid 82 escapes to the ambient atmosphere, if second supply fluid 82 is air as preferred or another gas, while retrieved oil 48 falls into reservoir 30. If second supply fluid 82 is liquid, both the liquid and spilled oil 44 will fall into reservoir 30.

Reservoir 30 is a container having a bottom 180 and a side wall portion 182 completely surrounding the perimeter thereof. Once full, reservoir 30 is transported from the spill area for further processing or proper disposal. As an example, if apparatus 10 is employed at sea for recovering spilled oil 44, apparatus 10, excluding reservoir 30, can be attached to a ship (not shown) and selectively lowered into the sea at areas of high concentration of spilled oil 44. Transporting conduit system 28 can then be configured to transport retrieved oil 48 to reservoir 30 located on a barge (not shown) so that a barge of retrieved oil 48 can be pulled away for further processing while the rest of apparatus 10 remains in place to fill the next empty barge. Alternatively, reservoir 30 can be fluidly connected to an additional conduit piping system (not shown) which can transport retrieved oil 48 for further processing or disposal without moving reservoir 30.

The following is an example of a specific application of apparatus 10: Under ambient conditions, heat exchanger 22 was placed in oil 44 in the form of motor oil of grade SAE 10W-30. Pressurized fluid 40 in the form of air and at a constant pressure of 125–130 psi proceeded through apparatus 10 as valves 52 and 54 were opened, valve 103 was partially opened, and valve 56 remained closed. Thus, first supply fluid 80 in the form of high pressure air was passed through vortex tube 18. Cold fluid 112 in the form of cold air then began to exit from cold pipe section 108 and released fluid 127 in the form of air began to become hot as it exited from exhaust outlet 126. The pressurized air 40 was allowed to pass through apparatus 10 until the temperature of hot fluid 42, as measured by temperature gauge 118, reached a steady state. Specifically, the steady state temperature of hot fluid 42 was measured to be 167.1 F. by temperature gauge 118. Valve 56 was then fully opened, and second supply fluid 82 in the form of air passed therethrough to jet pump 26 where retrieved oil 48 and the second supply fluid 82 formed mixture 168. Mixture 168 proceeded from jet pump 26 through outlet 172. The temperature of oil 44 entering jet pump 26 was measured to be 102 F. by temperature gauge 138. After 15 minutes, 294 ml of oil 44 was accumulated in reservoir 30. With the pressurized air 40 lowered to a constant pressure of 95–100 psi, 436 ml of oil 44 was accumulated during the same time frame. Since the jet pump 26 for this application was designed to be more efficient at 80–100 psi, pressurized air 40 at 95–100 psi accumulated more oil 44 than the same system at the higher air pressure.

Further embodiments of apparatus 10 are possible which take advantage of the fluids which are discharged and then

no longer used by apparatus 10. For instance as seen in FIG. 2, released fluid 127 from heat exchanger 22 and/or the second supply fluid 82 exiting pipe section 170, if second supply fluid 82 is a gas, can be fluidly coupled into supply conduit system 16 for returning to vortex tube 18 and/or jet pump 26. More specifically, released fluid 127 from heat exchanger 22 can be fluidly coupled to pipe section 58 to form a closed-loop system of heated fluid and to supply a warmer pressurized fluid 40 to vortex tube 18. Additionally, cold exhaust pipe section 108 can be fluidly coupled to supply conduit system 16. In particular, cold fluid 112 from vortex tube 18 can be fluidly coupled to pipe section 58 or pipe section 62 to conserve pressurized fluid. It should be understood that each of the above-mentioned examples of embodiments taking advantage of or recycling the fluids that are discharged can be used by itself or in combination with other fluid recycling embodiments.

It should be understood that the size and specific characteristics of apparatus 10 and all of the elements thereof will be dictated by the amount and type of the substance to be retrieved. For example, a more powerful jet pump 26 producing greater suction is needed for retrieving crude oil from bodies of water located in cold environments than is needed for retrieving refined oil spilled in rivers located in warm environments. The practical limitations of the deployment of apparatus 10, such as its ability to be transported to remote locations will also be a factor in the size and specific characteristics of apparatus 10.

Also, although apparatus 10 has been described with respect to retrieving spilled oil 44 from bodies of water, apparatus 10 can function equally as well retrieving fluids other than oil, such as, harmful chemicals. Further as seen in FIG. 3, apparatus 10 can be employed for retrieving spilled fluids from land as well as from sea. For example, a spilled fluid, such as oil, that is located in a desert 49 can be retrieved with the use of a more shallow heat exchanger 22. Additionally, since jet pump 26 uses no moving parts, the functioning of apparatus 10 is not threatened by the presence of sand 43 mixed with the oil 44, and can easily extract the polluted sand 43 along with the oil 44.

Still further, although apparatus 10 is disclosed as including vortex tube 18 and jet pump 26 together, other devices can be used in place of either vortex tube 18 or jet pump 26. For example, apparatus 10 can be configured such that vortex tube 18 is used as described above, but with a retrieving device different than jet pump 26, for instance, a conventional rotary vacuum pump with movable parts. Also, apparatus 10 can be configured such that jet pump 26 is used as described above, but without a heating device, or with a heating device different than vortex tube 18, for instance, a heating device with movable parts powered by an engine.

While an advantageous embodiment has been chosen to illustrate the invention, it will be understood by those skilled in the art that various changes and modifications can be made therein without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. An apparatus for collecting a substance, comprising:
 - a fluid source means for providing a first and a second pressurized fluid;
 - a heating device coupled to said fluid source means and being adapted to heat the first pressurized fluid from said fluid source means;
 - a heat transferring device coupled to said heating device for receiving the heated first pressurized fluid, and being adapted for transferring heat from the first pressurized fluid to a heatable substance; and

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a vacuum producing device having first and second inlet openings, said first inlet opening fluidly coupled to said fluid source means for receiving a second pressurized fluid from said fluid source means and said second inlet opening being adapted for receiving the heatable substance. 5

2. An apparatus according to claim 1, wherein said vacuum producing device has an outlet opening fluidly coupled to said first and second inlet openings for allowing the second pressurized fluid and the heatable substance to exit said vacuum producing device. 10

3. An apparatus according to claim 2, wherein said vacuum producing device is formed entirely of stationary elements. 15

4. An apparatus according to claim 3, wherein said vacuum producing device is a jet pump.

5. An apparatus according to claim 1, wherein said fluid source means provides pressurized gas.

6. An apparatus according to claim 5, wherein said fluid source means comprises a single source of pressurized gas fluidly coupled to both said heating device and said vacuum forming device. 20

7. An apparatus according to claim 1, wherein said heating device has a first aperture fluidly coupled to said fluid source means, a second aperture fluidly coupled to said heat transferring device, and a connecting portion positioned between said first and second apertures and fluidly coupling said first and second apertures together, and wherein said heating device is comprised entirely of stationary elements. 25 30

8. An apparatus according to claim 7, wherein said connecting portion of said heating device is configured such that a vortex is formed within said heating device by the first pressurized fluid. 35

9. An apparatus according to claim 1, wherein said heat transferring device is partially enclosed by an insulating housing to maintain heat within the heatable substance once transferred by the heat transferring device. 40

10. An apparatus according to claim 1, wherein said heat transferring device has an end portion which is directly coupled to and in fluid communication with said fluid source means to return the first pressurized fluid to said fluid source means. 45

11. An apparatus for collecting a substance, comprising: a fluid source means for providing a first and a second pressurized fluid; 50

a heating device having a first aperture fluidly coupled to said fluid source means, a second aperture, and a connecting portion positioned between said first and second apertures and fluidly coupling said first and second apertures together, and said connecting portion configured such that a vortex is formed within said heating device by the first pressurized fluid from said fluid source means and such that the first pressurized fluid becomes heated within said heating device; 55

a heat transferring device fluidly coupled to said second aperture of said heating device for receiving the heated first pressurized fluid, and said heat transferring device being adapted for transferring heat from said first fluid to a heatable substance; and 60

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a vacuum producing device adapted for extracting the heatable substance from an area around said heat transferring device.

12. An apparatus according to claim 11, wherein said heating device is formed entirely of stationary elements.

13. An apparatus according to claim 12, wherein said heating device is a vortex tube, and said vortex tube is adapted to cool a portion of the first pressurized fluid.

14. An apparatus according to claim 13, wherein said heating device has an end portion which is directly coupled to and in fluid communication with said fluid source means to return the cool portion of the first pressurized fluid to said fluid source means.

15. An apparatus according to claim 11, wherein said fluid source means further provides pressurized gas; said vacuum producing device has first and second inlet openings, said first inlet opening fluidly coupled to said fluid source means for receiving the second pressurized fluid from said fluid source means, and said second inlet opening being adapted for receiving the heatable substance.

16. An apparatus according to claim 15, wherein said vacuum producing device has an outlet opening fluidly coupled to said first and second inlet openings for allowing the second pressurized fluid and the heatable substance to exit said vacuum producing device.

17. An apparatus according to claim 16, wherein said vacuum producing device is formed entirely of stationary elements.

18. An apparatus according to claim 17, wherein said vacuum producing device is a jet pump.

19. An apparatus according to claim 15, wherein said fluid source means comprises a single source of pressurized gas fluidly coupled to both said heating device and said vacuum forming device.

20. An apparatus for collecting a substance, comprising: a fluid source means for providing a first and a second pressurized fluid; 50

a heating device coupled to said fluid source means and being adapted to heat the first pressurized fluid from said fluid source means;

a heat transferring device coupled to said heating device for receiving the heated first pressurized fluid, and transferring heat from the first pressurized fluid to a heatable substance which is spaced from and is not contacting any supporting liquid; and

a vacuum producing device having first and second inlet openings, said first inlet opening fluidly coupled to said fluid source means for receiving a second pressurized fluid from said fluid source means and said second inlet opening receiving said heatable substance.

21. An apparatus according to claim 20, wherein said heatable substance is a mixture of a petroleum product and a granular element.

22. An apparatus according to claim 21, wherein said petroleum product is oil and said granular element is sand.